

The Production, Composition and Mineralization Rate of Litter  
in Two Forest Associations in Western Carpathians: *Tilio-Carpinetum*  
(Pogórze Wielickie Region) and *Fagetum carpaticum* (Gorce Mts.)

by

K. TOWPASZ

Presented by J. KORNAŚ on January 14, 1976

**Summary.** The investigations were carried out in 1974 in two forest patches: that of the *Tilio-Carpinetum* association in the Pogórze Wielickie region near the town Bochnia (off Cracow) and that of *Fagetum carpaticum* in the Poniczanka rivulet valley in the Gorce Mts. The obtained results indicate the of litter production depending on litter composition and give a tentative evaluation of its decomposition and rate of mineralization.

This study was carried out as part of the comprehensive research project concerning the problem of "Biological productivity". The investigations were carried on in 1974 parallelly in the two forest associations mentioned in the title. The results obtained contribute to the knowledge of litter appearance and subsequent decrement in the above-mentioned associations.

The investigated areas

*The study area in the Pogórze Wielickie region at Kolanów.* Situated about 40 km SE of Cracow (49°57' N and 20°24' E) at an altitude of 340 m a.s.l., it is a stand of the *Tilio-Carpinetum* association of 0.5 ha total area. *Carpinus betulus* dominated the trees layer; much less frequent were *Quercus robur*, *Populus tremula* and *Betula verrucosa*. The diameter of the trees was between 10 and 25 cm, and their height 10—13 m. The herb layer was dominated by *Galeobdolon luteum* and *Milium effusum*, and *Anemone nemorosa* in the spring [11].

The studied association growing on brown forest soil was situated in a temperate warm vertical climatic zone [4]. Over the period of the study, the mean annual temperature as recorded in the nearby climatic station Bochnia-Chodenice (49°58' N and 20°23' E) was +9.9°C, with the mean for January at +0.2° and that for July at +16.3°, whereas mean annual precipitation was recorded to be 959 mm [6].

*The study area in the Gorce Mts. in the Poniczanka rivulet valley* is situated about 80 km S of Cracow (49°33' N and 19°58' E) at an altitude of 880 m a.s.l. in a stand of the *Fagetum carpaticum* association. It comprises an area of 0.5 ha. The tree layer was dominated by *Fagus sylvatica*; *Abies alba* was much less frequent, and *Picea excelsa* occurred sporadically. The trees had diameters between 15 and 30 cm, and their height ranged from 18 to 25 m. The herb layer was dominated by

*Oxalis acetosella* and *Asperula odorata*, and by *Dentaria glandulosa* and *D. bulbifera* as well as *Anemone nemorosa* in the spring [13].

The studied plot growing on leached brown soil was located in a temperate cool vertical climatic zone [4]. The mean annual temperature recorded in 1974 for the locality Ponice was  $+6.7^{\circ}\text{C}$ , with  $-1.2^{\circ}$  as the mean for January and  $+13.6^{\circ}$  for July; mean annual precipitation was 1348 mm [8].

### Methods

In the spring of 1974, ten organic litter traps were installed in randomly selected points over the *Fagetum carpaticum* stand. Each trap was made of a metal hoop supported on metal legs and suspended with a linen bag fastened to it about 80 cm above the ground. The area of the trap encircled by the hoop totalled 1250 cm<sup>2</sup>. Similar traps installed in the *Tilio-Carpinetum* stand were damaged. The traps were emptied at about 4-week intervals (or at 2-week intervals during the autumn) from April through November. The collected material was divided into fractions: leaves, bract, seeds, and fruits (twigs were discarded), dried at  $85^{\circ}\text{C}$ , and weighed with accuracy up to 0.001 g.

Moreover, litter samples were taken from the forest floor in both study areas from April to November (7 times in *Tilio-Carpinetum*; 6 times in *Fagetum carpaticum*) in order to analyse the composition and rate of decrement of the litter. Litter decrement over the winter period was estimated from one sample-series taken in the spring of 1975 (from *Tilio-Carpinetum* in April, and from *Fagetum carpaticum* in March). All those samples were taken together with samples of the herb layer [11, 13] by means of a metal hoop, its contour cutting into the soil to collect the litter as far as the mineral layer surface. In the *Tilio-Carpinetum* a single series included 25 samples of 1/16 m<sup>2</sup> area each, and in the *Fagetum carpaticum* it included 5 samples of 1/8 m<sup>2</sup> each. The material was segregated into the particular fractions to estimate the degree of decomposition for each of them and subsequently to dry them at  $85^{\circ}\text{C}$  and weight with accuracy up to 0.001 g.

To estimate the decomposition of the litter and its rate of decrement in the two areas, from April 1974 litter samples were put out in torlene bags (of 2 mm mesh). Then they were collected at 4-week intervals, brought to the laboratory, dried at  $85^{\circ}\text{C}$ , weighed and, after a few days, sent back to their area. These observations were carried on in the *Tilio-Carpinetum* stand till April 1975, and in that of *Fagetum carpaticum* till March.

Litter production in *Fagetum carpaticum* was estimated in two ways: by adding up the data for organic fall collected in the particular periods in the traps, and from the litter samples collected from the forest floor after the litter fall had passed its maximum (subtracting the quantity of undecomposed litter deriving from the previous seasons).

For reasons mentioned before, litter production in the *Tilio-Carpinetum* stand was estimated only from samples taken from the forest floor.

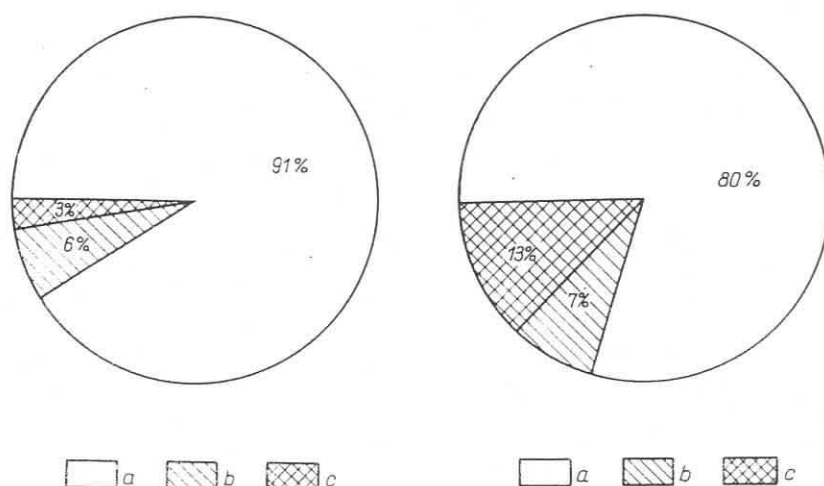
### Results

As estimated from samples taken from the forest floor in November, litter production in *Tilio-Carpinetum* was 3.8 tons per hectare. In *Fagetum carpaticum*, litter production was found to be 3.4 t/ha (from samples from the forest floor) and 3.5 t/ha (from traps).

During its maximum value, i.e. in November, the litter fall was dominated by leaves: they accounted for 91% of it in *Tilio-Carpinetum* and for 80% in *Fagetum carpaticum* (twigs were not taken into the total fall quantity) — see Figs. 1 and 2.

*Carpinus betulus* was the species dominating the *Tilio-Carpinetum* stand: it accounted for about 70% of the total leaf fall. The two other species, *Populus tremula* and *Quercus robur*, accounted for 14.4% and 12.5% of the fall quantity, respectively. In the *Tilio-Carpinetum*, the litter consisted predominantly of leaves from

fall during the study year, and undecomposed litter from the previous year accounted for of mere 20 % only. In *Fagetum carpaticum* the leaf litter fall was composed entirely of leaves of *Fagus silvatica*; only the uppermost undecomposed litter horizon (L) came from last year's fall, the remaining horizon (F) was deposited on the forest floor for several years representing different phases of decomposition. In the studied plot the upper layer accounted for a mere 25 % of the total litter quantity.



Figs 1—2. Composition of the litter fall during its maximum in the *Tilio-Carpinetum* (left) and *Fagetum carpaticum* (right) associations (percentages)

a — leaves, b — seeds and fruits, c — others

The quantitative data concerning the leaf litter fall in both associations are collected in the Table. Calculated with a planimeter as an average of 100 leaves, the total area of one leaf was bigger in *Tilio-Carpinetum* than in *Fagetum carpaticum* (32.0 vs. 19.6 cm<sup>2</sup>, respectively). Conversely, the number of leaves and the index of total leaf area were found to be higher in *Fagetum carpaticum* ( $36.8 \cdot 10^6$  leaves per 1 ha, and 7.21 ha/ha) than in *Tilio-Carpinetum* ( $27.9 \cdot 10^6$  leaves per 1 ha and 6.44 ha/ha).

TABLE

Data on leaf litter fall in the *Tilio-Carpinetum* and *Fagetum carpaticum* associations in 1974

Association	Leaves	<i>s</i> (cm <sup>2</sup> )	<i>S</i> (ha/ha)	<i>F</i> (kg/ha)	N/ha
<i>Tilio-Carpinetum</i>	<i>Carpinus</i>	21.5 ± 1.4	5.22	2309.7	24.3 · 10 <sup>6</sup>
	<i>Quercus</i>	48.4 ± 3.8	0.62	409.7	1.3 · 10 <sup>6</sup>
	<i>Populus</i>	26.2 ± 1.5	0.60	471.5	2.3 · 10 <sup>6</sup>
<i>Fagetum carpaticum</i>	<i>Fagus</i>	19.4 ± 2.0	7.21	2692.0	36.8 · 10 <sup>6</sup>

*s* — single leaf surface area, *S* — total leaf surface area, *F* — leaf fall quantity, *N* — number of leaves

The decrement of litter in the *Tilio-Carpinetum* association from April 1974 to April 1975 is shown in Fig. 3. The total decrement was found to have been 257 g/m<sup>2</sup> or 84.8%. The decrement of individual components of the litter was investigated from April to November 1974. The number of leaves decomposed for the different species was as follows: 148 g for *Carpinus*, 34 g for *Populus*, and 20 g for *Quercus* (per m<sup>2</sup> all). These correspond to 75.0, 74.9, and 64.2%, respectively.

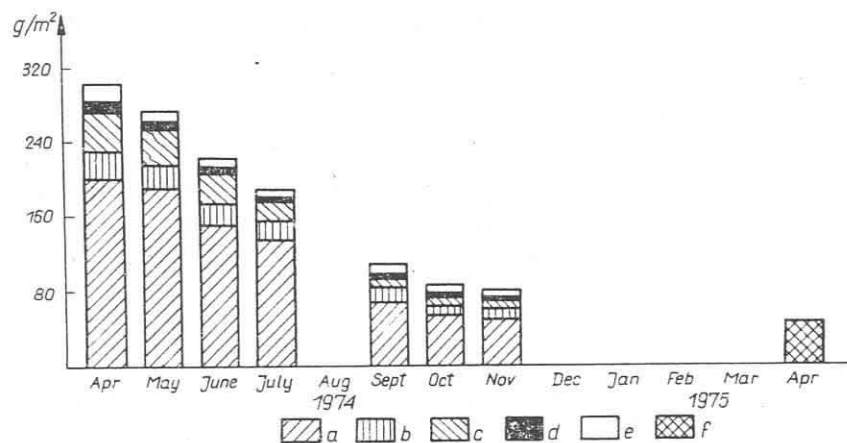


Fig. 3. Decrement of litter components in the *Tilio-Carpinetum* association (g/m<sup>2</sup>)

a — *Carpinus betulus*, b — *Quercus robur*, c — *Populus tremula*, d — leaves from the other tree species, e — others, f — fragments of strongly decomposed litter

The decrement of litter of *Tilio-Carpinetum* in samples taken directly from the forest floor is compared to that in samples put out in torlene bags. Over the one-year period of April 1974 to 1975, the decrement percentage values were 84.8 and 62.6, respectively.

The rate of litter decomposition during the year varied. It was found to be fairly high in samples taken from the forest floor till October: 72.7%. From October 1974 through April 1975 the rate of decomposition declined (12.1%). In the samples put out in the torlene bags from April to November, 57.8% of the litter decomposed, and later till April 1975 only 4.8%.

The decrement of litter in *Fagetum carpaticum* from April to March was 387 g/m<sup>2</sup> and is shown in Fig. 4.

The decrement of litter in samples from the forest floor as compared to that in samples put out in the torlene bags is shown in Fig. 6. Over the period of April 1974 to March 1975 the respective values were 32.7% and 23.8%. The rate of decomposition of litter in samples from the forest floor was lower from May to July (4.1%), then the decomposition rate rose and kept at a higher level till September (21.8%), and till March of the next year the rate again declined (6.9%). The pattern of variation of the decomposition rate was similar for the samples put out in the

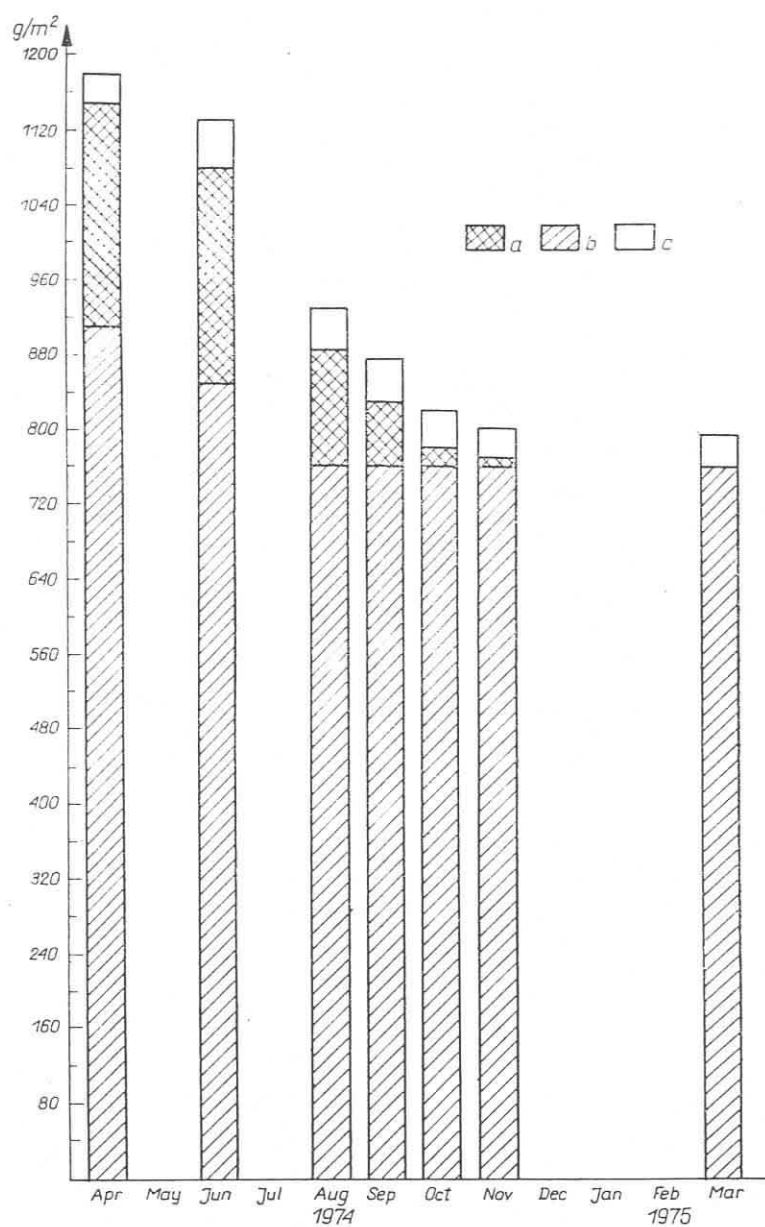


Fig. 4. Decrement of litter components in the *Fagetum carpaticum* (g/m<sup>2</sup>)

a — *Fagus*, whole leaves (L horizon), b — *Fagus*, strongly decomposed leaves (F horizon), c — others

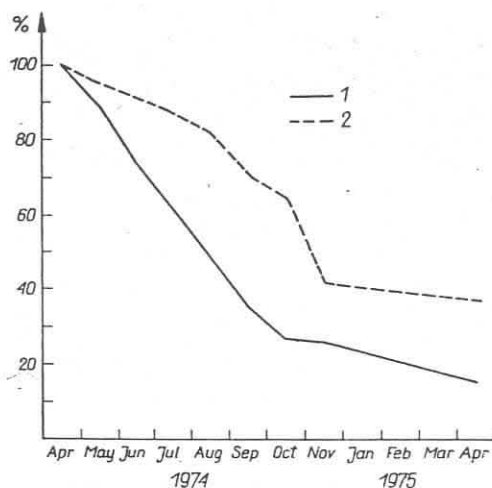


Fig. 5. Litter decrement in the *Tilio-Carpinetum* association (percentages)

1 — samples from the forest floor, 2 — samples from torlene mesh bags

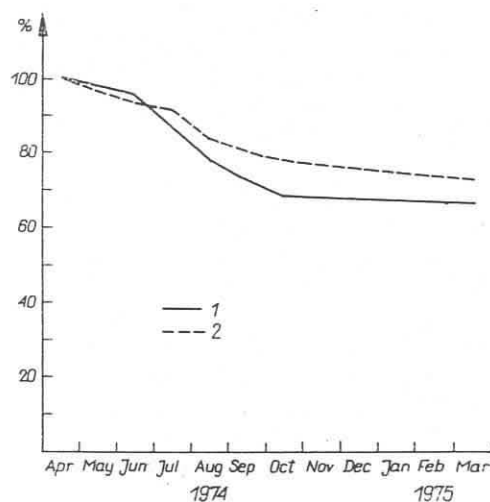


Fig. 6. Litter decrement in the *Fagetum carpaticum* association (percentages)

1 — samples from the forest floor, 2 — samples from torlene mesh bags

torlene bags. In the period of April through July the rate of decomposition was lower (8.1%). The rate rose in the period July-September (11.3%), and next it fell till March next year (7.4%).

#### Discussion

Some results on the production of the herb layer have been recently published in this Bulletin [11, 13]. A more detailed description of the two plot and a discussion of litter production are being prepared for publication [12].

In 1974 litter production was slightly higher in *Tilio-Carpinetum* than in *Fagetum carpaticum* (3.8 and 3.4 t/ha, respectively). Similar results concerning litter production in the two associations were obtained by other authors [1, 2]. The data concerning leaf litter fall (such as leaf surface area, leaf surface index) did not differ significantly from those cited in the literature [3, 5]. These values vary depending on climatic conditions in the given year (especially air temperature and precipitation). The appearance of pest insects, notably *Tortrix viridana*, may also affect litter production [3, 5].

The quantity of litter decomposition in the studied period was mainly dependent on the species constituting the community. The litter quantity deposited on the *Tilio-Carpinetum* stand was during the one-year period 2.5 times higher than that in *Fagetum carpaticum*. The rate of decomposition differed from species to species, which had also been observed by other authors [1, 7]. The highest rate of decomposition was observed for *Carpinus betulus* 75.0% and *Populus tremula* (74.9%); those for *Quercus robur* and *Fagus sylvatica* were lower (64.2% and 32.7%, respectively).

Litter decomposition was also dependent on the different climatic conditions for the two plot the year (especially air temperature and humidity) [14]. It rose with both air temperature and humidity which explains the growing rate of decomposition in the summer-autumn season (Figs. 3—6).

The litter placed in the torlene bags with a 2 mm mesh was observed to decompose slower. This was due to the impeded movement freedom for the larger soil fauna (mainly earthworms) and gives evidence of their role in the decomposition of the litter. More pronounced differences were recorded in the decomposition of litter in *Tilio-Carpinetum* than in *Fagetum carpaticum* (Figs. 5, 6).

The index of decomposition calculated on the basis of annual litter fall related to the litter quantity deposited on the forest floor [9, 10] was 0.8 for *Tilio-Carpinetum* and 0.3 for *Fagetum carpaticum*. These value indicate that complete decomposition, and thus the total turnover of organic matter, took a period of about 1.5 year in *Tilio-Carpinetum* and 3 years in *Fagetum carpaticum*.

INSTITUTE OF BOTANY, JAGIELLONIAN UNIVERSITY, LUBICZ 46, 31-512 CRACOW  
(INSTYTUT BOTANIKI, UJ)

#### REFERENCES

- [1] E. Bandoła, Ciołczyk, *Studia Naturae*, Sér. A, 9 (1974), 29.
- [2] R. J. Bray, E. Gorham, *Adv. Ecol. Res.*, 2 (1964), 101.
- [3] A. Carlisle, A. H. F. Brown, E. J. White, *J. Ecol.*, 54 (1966), 65.
- [4] M. Hess, *Zeszyty Nauk. UJ., Prace Inst. Geogr.*, 33 (1965), 1.
- [5] H. Hytteborn, *Acta Phytogr. Suecica*, 61 (1975), 1.
- [6] IMiGW, [unpublished data].
- [7] M. Karkanis, *Fragm. Flor. et Geobot.*, 21 (1975), 71.
- [8] J. Klein, [unpublished data]
- [9] B. Nihlgard, *Oikos*, 23 (1972), 69.
- [10] A. Stachurski, J. R. Zimka, *Ekol. Pol.*, 23 (1975), 103.
- [11] K. Towpasz, *Bull. Acad. Polon. Sci., Sér. Sci. Biol.*, 24 (1976), 205.

- [12] K. Towpasz, D. Tumidajowicz, [unpublished data].  
[13] D. Tumidajowicz, Bull. Acad. Polon. Sci., Sér. Sci. Biol., [in press].  
[14] S. T. Williams, T. R. G. Gray, *Decomposition of litter on the soil surface*, in: *Biology of plant litter decomposition*, London—New York, 1974, pp. 611—632.

К. Товпаш, Продукция подстилки, её состав и скорость минерализации в двух лесных ассоциациях западных Карпат: *Tilio-Carpinetum* (Велицкое Погорье) и *Fagetum carpaticum* (Горше)

Содержание. В работе представлено результаты годовых исследований продукции подстилки и её состава, а также скорости распада в двух лесных ассоциациях — *Tilio-Carpinetum* и *Fagetum carpaticum*. В случае *T.-C.* продукция подстилки была более высокая (3,8  $m/za$ ), чем в *F. carpaticum* (3,4  $m/za$ ). В подстилке *T.-C.* листья составляли 91%, а в *F. carpaticum* 80% годичного падения. В ассоциации *T.-C.* преобладал *Carpinus betulus* — 70% падения, значительно меньше было *Populus tremula* и *Quercus robur*. Подстилка этой ассоциации состояла главным образом из листьев из последнего падения, участие неразложившейся подстилки из предыдущего сезона было небольшое. В ассоциации *F. carpaticum* падение состояло из листьев *Fagus sylvatica* образуя только верхнюю часть подстилки. Нижний неразложившийся слой подстилки лежал на дне леса на протяжении нескольких лет. Годовой убыток подстилки и скорость разложения исследовано на основании периодических проб из дна леса и проб подстилки хранившихся в торловых мешочках. Оказалось, что процесс разложения подстилки находящейся в мешочках происходил медленнее: в *T.-C.* в первом случае — 84,8%, во втором — 62,6% а в *F. carpaticum* — 32,7% и 23,8%, соответственно. Индекс разложения подстилки исчисленный на базе отношения годового падения к количеству залегающей подстилки на дне леса был для *T.-C.* 0,8 а для *F. carpaticum* 0,3. Полное разложение подстилки для *T.-C.* — около 1,5 года, а для *F. carpaticum* — около 3 лет.